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Supply Chain Innovation in Scientific Research Collaboration

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Received: 6 December 2018; Accepted: 29 January 2019; Published: 31 January 2019

Abstract: Innovations in supply chains and logistics, which help businesses reduce their costs and meet customer needs, have become increasingly vital. In this study, we first conducted a content analysis followed by a social network analysis to systematically review 104 research papers on supply chain innovation (SCI) that were published between 1987 and 2018. The results suggest that SCI research was originally concentrated in the United States and did not receive much attention in Europe and Asia, until more recently. An analysis of collaboration networks indicates that an SCI research community has just started to form, with the United Kingdom at the center of the international collaborative network. Implications of the study and directions for future research are summarized in detail, based on the systematic literature review.

Keywords: supply chain innovation; systematic review; social network analysis; collaboration

1. Introduction

In today's highly competitive global market, effective logistics innovation (LI) and supply chain innovation (SCI) play a key role in improving the organizational performance and competitive advantage of companies [1]. During the past few decades, new business models based on new logistics flows and supply chains have emerged [2]. SCI includes new production, marketing, or logistics processes that use technology and process innovations to generate information processing and new logistics services, improving operational efficiency and service effectiveness [3]. LI is seen as a new and innovative service related to logistics, whether basic or complex, which is particularly beneficial to specific stakeholders [4]. By comparing broader supply chain management with logistics management, we can deduce that the definition of SCI is more extensive than that of LI. Therefore, this study uses the term SCI to reflect this broader scope, including LI.

Competitive pressures and turbulent business environments are driving companies to innovate to ensure their survival, accelerate transformation, or support growth [5]. Among the activities in various sections of a supply chain, such as purchasing, material management, production, distribution, and marketing, one of the biggest challenges is meeting customer requirements while managing costs. Depending on the economy's level of development, the total supply chain cost accounts for, on average, approximately 5% to 10% of a company's annual income [6–8]. According to the GMA 2010 Logistics Benchmark Report, effectively reducing logistics costs has become a major goal for supply chains of US companies in 2008 and 2010 [7]. Cooperation allows supply chain participants to create complementary effects within innovation [9,10]. Therefore, SCI is regarded as a necessary tool.

LI and SCI are also becoming popular topics in the academic community [9]. An increasing numbers of scholars have begun reviewing supply chain innovation, such as supply chain collaboration [11], innovation process [2], network configuration [6,12], information technology [13,14], and sustainable development [15,16]. Kwak et al. [17] examined the effects of SCI on risk management capabilities based on 174 Korean manufacturers and logistics intermediaries; the results showed that SCI has a significantly positive effect on both the robustness and the resilience of risk management capabilities and, in turn, exerts a significant effect on the enhancement of competitive advantage. Abdelkafi and Pero [3] adopted a qualitative research tool to investigate how companies can use SCI to generate new business models; they found that SCI is primarily used to solve specific operational issues and often leads to incremental innovation of business models, but rarely results in radical innovation. Innovations can also lead to positive logistics business performance and customer satisfaction [18,19]. Wang et al. [20] pointed out that innovation performance may be negatively affected by certain supplier–client contracts. Lastly, in knowledge-intensive industries, value-creating activities are dispersed among the specialized companies in the supply chain, and the key companies serve as the controllers of the network and the knowledge integrators. Under this context, the difficulties faced by these key companies in knowledge integration are deemed obstacles to innovation [21].

Furthermore, the collaborative research team is a necessary and ideal component in the development of emerging research fields. Cooperation and networking are beneficial and useful strategies to increase productivity and influence research activities [22]. Interaction between researchers is expected to create new knowledge and expedite knowledge transfer. Cooperation between researchers is a laudable goal, one that has also been accepted and promoted by many policymakers [23]. Research projects funded by the European Union and China will include researcher cooperation as one of the necessary conditions to guarantee research funding.

In recent years, cooperation in academic research has become increasingly diversified across institutions, professions, practices, and countries. Adopting an interdisciplinary research strategy enhances the coherence and social relevance of the results that researchers produce [24]. Chen et al. [25] mentioned that scholars and practitioners have taken actions to cooperate through conferences, forums, and professional education courses. The research capabilities of major countries in Europe and Asia have been substantially improved and have had a major impact on the research environment that was previously dominated by American universities [26]. Advances in communications technology also enhance researcher cooperation, which may even be international [14,27].

The main purpose of this study is to analyze literature in the SCI field using content analysis and social network analysis (SNA) in a systematic review. The first contribution offered by this study is an overall picture of the field of SCI. Second, it allows readers to understand which topics researchers address in their discussions of SCI. Third, through academic collaboration relationships, it allows us to understand growth and changes in the SCI community. Finally, it reveals the finding that the field of SCI requires additional collaboration between academia and industry.

The rest of this paper is arranged as follows: Section 2 details the structured methodology used for literature review and evaluation in this study, Section 3 illustrates the analytical results, and Section 4 offers insights in terms of future research directions and conclusions.

2. Methodology

In the present study, we performed a systematic review to analyze SCI articles. The content analysis focused on published works rather than on data collection [28]. The steps of the systematic review process were (1) identification of suitable keywords and search queries; (2) compilation of a consideration set; (3) specification of eligibility criteria and assessment; (4) data processing and analysis; and (5) classification and typology of the results [29–31].

The study carried out independent searches using Scopus and the Web of Science to search the following keywords: “logistics innovation” and “supply chain innovation.” Scopus is the world’s largest abstract database that covers over 21,000 titles from peer-reviewed journals, conference proceedings, books, and business journals to ensure its multidisciplinary nature. The Web of Science is a citation index service developed by the Institute for Scientific Information; it grants access to literature and abstracts published in over 12,000 journals in the areas of science, engineering, medicine, agriculture, humanities, and social sciences.

Table 1 summarizes the articles retrieved and selected. To determine whether a study should be included, the inclusion and exclusion criteria were (1) the article is in English; (2) the article is from a peer-reviewed journal; (3) repeated, retracted, or articles published as conference papers, notes, comments, books, magazines, or trade publications, were excluded; (4) the article is relevant to the search terms defined in Section 1. The full texts of 142 articles were analyzed, and those not related to SCI were eliminated from the sample. In total, 104 SCI-related articles, published between 1987 and 2018, were selected.

Table 1. Summary of keyword searching.

Database	Keyword Search	English only	Full Paper Analysis	Final Analysis
Scopus				
SCI	125	119	142	104
LI	71	69		
Web of Science				
SCI	41	41		
LI	17	17		

Notes: SCI refers to supply chain innovation; LI refers to logistics innovation.

These SCI-related articles were reviewed systematically through content analysis, and each was examined twice to derive data of interest. All the articles were analyzed under the themes of descriptive statistics, collaboration, methodology, and theory. Data from descriptive statistics encompassed the following categories: distribution of the articles, country of data collection, and topic of research [9,16]. Subsequently, the collaborative relationships indicated in the articles were analyzed by author name, affiliation, and country [27]. Moreover, the theories used in the articles were summarized [16]. Finally, to elucidate trends in SCI research, we divided articles by publication period into two groups, 1987–2011 and 2012–2018, and compared them; this was because the number of SCI-related articles published, per year, during the 2012–2018 period was more than ten times that during the 1987–2011 period (see Figure 1).

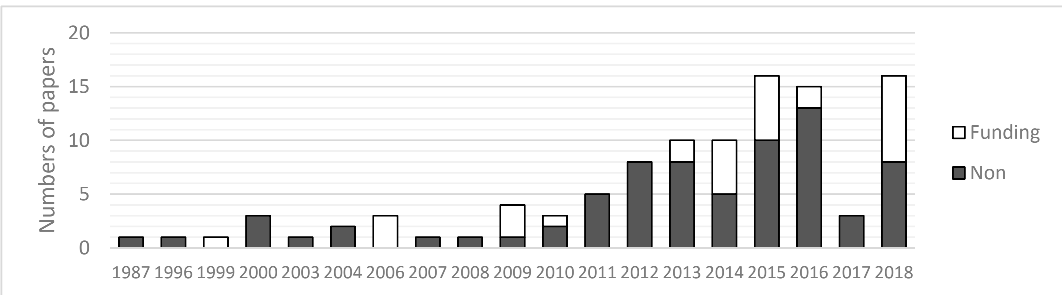


Figure 1. Distribution of reviewed papers by year.

3. Results

This section presents the results of the analysis of the SCI-related articles in terms of descriptive statistics, research collaboration, and theory analysis.

3.1. Descriptive Statistics

Figure 1 presents the number of funded and nonfunded SCI-related articles by year between 1987 and 2018. On average, the number of SCI-related articles published, from 1987—when the first

SCI-related article was published—to 2011, was fewer than two per year (standard deviation = 1.45). However, this figure is more than seven times higher in 2012, when eight SCI-related articles were published. No SCI-related articles were published in certain years prior to 2006. These results indicate that SCI research needed more attention during the 1987–2011 period. Moreover, the majority of published SCI-related studies were undertaken without funding from any organization (74.15%). In 1999, 2006, 2009, 2014, and 2015 only, over 30% of SCI-related studies were funded. This suggests that the number of published SCI-related studies with funding did not increase as the body of SCI research expanded. Benner and Sandström [32] noted that funding is a crucial mechanism underlying the reform of a regulatory system, because the reward framework in the system influences the research performance and appraisal. Additionally, in the United States and other countries, funding is one of the most crucial policies for fostering industrial development [33]. SCI can significantly shorten the cycle of new product introduction, lower inventory, increase the frequency of customer feedback, and improve decision-making processes [13]. Thus, more funds should be invested in promoting SCI research and application.

Table 2 categorizes SCI-related articles by the geographic region in which the studies were undertaken. Among the 104 SCI-related articles, 19 did not mention the region where the data were collected, while some covered either multiple countries (n = 7), or just the European Union (n = 7), or the whole world (n=2). Over the 1987–2018 period, most of the studies were conducted in the United States (n = 20), followed by Italy (n = 8), the European Union (n = 7), and India (n = 6). The top ten regions with the most SCI-related studies were largely developed countries. Furthermore, between 1987 and 2011, most SCI research was conducted in the United States. This trend continued into the 2012–2018 period, when more researchers began to focus on Italy, China, the European Union, India, Denmark, and Taiwan. Therefore, SCI research was concentrated in the United States and spread to Europe and Asia, suggesting that American academia plays a leading role in the SCI field.

Table 2. Countries of focus.

Collaboration Form	1987–2011	2012–2018	Total
United States	7	13	20
Italy	0	8	8
European Union	1	6	7
India	1	5	6
China	0	5	5
Republic of Korea	2	3	5
Taiwan	1	4	5
Australia	2	2	4
Denmark	0	4	4
United Kingdom	1	3	4
German	0	3	3
Malaysia	0	3	3
Netherlands	2	1	3
Sweden	0	3	3

Note: shown only if >2.

The dynamics of SCI research topics are shown in Table 3. During the research period, academics primarily investigated SCI from the perspectives of adoption, collaboration, and green/sustainable development. From 2012 to 2018, researchers focused on the topics of green/sustainable development, managerial function, managerial tools, and collaboration. The topics of green/sustainable development and managerial tools experienced the fastest growth, accounting for more than 8% of total growth. Organizational performance and adoption have remained topics of interest among scholars [34].

Table 3. Topic profile.

Topics	1987–2011		2012–2018		Total	
Green/sustainable development	1	(3.8)	18	(28.6)	19	(21.3)
Collaboration	7	(26.9)	10	(15.9)	17	(19.1)
Managerial function	4	(15.4)	13	(20.6)	17	(19.1)
Adoption	7	(26.9)	9	(14.3)	16	(18.0)
Managerial tools	2	(7.7)	13	(20.6)	15	(16.9)
Organizational performance	5	(19.2)	8	(12.7)	13	(14.6)
Key success factor	1	(3.8)	5	(7.9)	6	(6.7)
Network	1	(3.8)	2	(3.2)	3	(3.4)
Others	3	(11.5)	3	(4.8)	6	(6.7)
Total	31	(119.2)	81	(128.6)	112	(125.8)

Note: 1. The numbers in parentheses are percentage; 2. Of the 104 articles, seven articles dealt with multiple topics.

3.2. Collaboration Networks

Table 4 summarizes the patterns of SCI collaboration in academic communities. Compared with the period of 1987–2011, in the period of 2012–2018, the proportion of articles written by single authors declined, and the rate of collaboration increased. This is indicative of the fact that, in recent years, researchers in the SCI field have published articles through collaboration. With regard to team collaboration patterns, collaboration is primarily conducted within a single institution (37.5%), followed by co-authorship among academics at the international level (26.0%). The extent of cross-sector collaboration at national (4.8%) and international (2.9%) levels is low. Furthermore, there has been a downward trend in the ratio of cross-sector collaboration in recent years. The most important studies were the result of researchers' personal involvement in practical activities or face-to-face interactions [35].

Table 4. Collaboration analysis.

Collaboration Form	1987–2011		2012–2018		Total	
Single authored	4	(15.4)	7	(9.0)	11	(10.6)
Institutional level	7	(26.9)	32	(41.0)	39	(37.5)
National level						
Among academics	6	(23.1)	13	(16.7)	19	(18.3)
Cross-sector collaboration	4	(15.4)	1	(1.3)	5	(4.8)
International level						
Among academics	4	(15.4)	23	(29.5)	27	(26.0)
Cross-sector collaboration	1	(3.8)	2	(2.6)	3	(2.9)
Total	26	(100.0)	78	(100.0)	104	(100.0)

Note: The numbers in parentheses are percentage.

After the 11 single-authorship SCI-related articles were eliminated from the sample, an SNA was performed to visualize collaboration networks based on authors' personal information, providing an insight into the collaboration in terms of authors (Figure 2), institutions (Figure 3), and countries (Figure 4). The collaboration networks shown in Figures 2–4 comprised (1) nodes, which represented authors, institutions, or countries; and (2) links which denoted one or more relationships that existed between nodes. A thicker link indicated more frequent collaboration between authors, institutions, or countries. The weight of a link is represented by the strength of the link. NodeXL, Ucinet, and Netdraw were used to visualize the collaboration networks and calculate their weight.

Figure 2 illustrates the co-authorships on degree centrality based on publications over the past three decades. Degree centrality is defined as the number of direct ties that a node has with other nodes in the network graph. Five co-authorship networks were relatively strong; these authors published at least two papers. In particular, these networks led by Hazen B.T., Habidin N.F., Shazazli N.A., Santa R., and Storer M. involved more scholars.

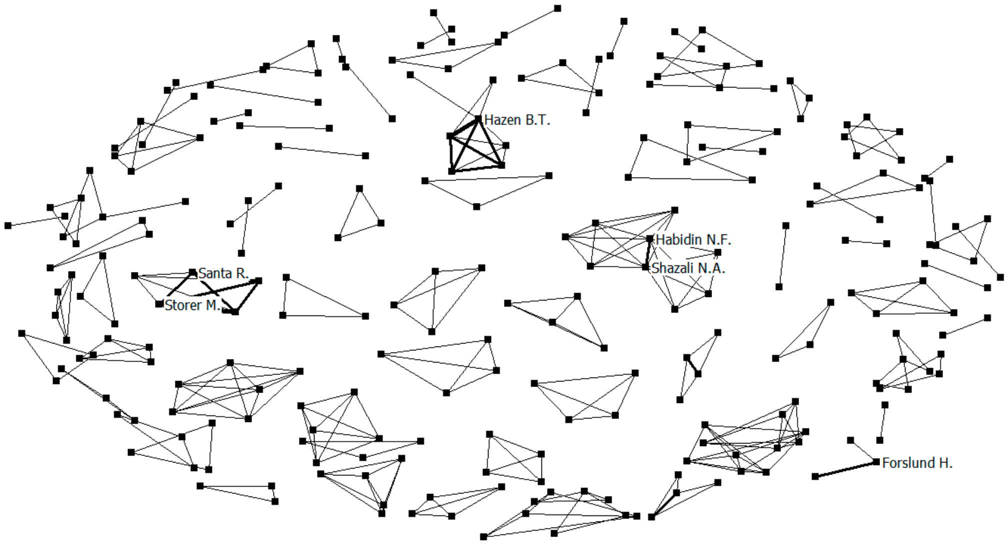


Figure 2. Co-authorship networks. Notes: 93 articles among 253 authors.

However, Figure 2 suggests that the collaborative relationships in SCI research were fragmented, and no connections were formed between different or unconnected clusters. As future SCI papers are indexed by Scopus and Web of Science, the collaboration networks will solidify.

The affiliations of SCI authors were also linked to explore institutional collaboration in SCI research. The co-institutional research collaboration on degree centrality based on publications is shown in Figure 3. Figure 3 indicates that some institutions, such as the Zhejiang University, University of Waikato, Xiamen University, Cardiff University, Politecnico di Milano, Stanford University, and Alfaisal University, were in a "structural hole" and could link with different clusters. The structural hole refers to the optimal position where an organization—capable of linking two or more partners or collaboration groups without any connection—can gain information and control benefits over these partners or collaboration groups [36].

Figure 4 depicts international collaboration networks in SCI research. In the figure, only four node-to-node networks appear over the 1987–2011 period; this is because a) co-authored studies were mostly conducted in the same countries, and b) productive researchers tended to work with colleagues in the same institutions [37]. However, a cross-national collaboration network centering on the United Kingdom formed during the 2012–2018 period. This echoes the results in Table 5. As the core issues as well as the data acquisition, analysis, and interpretation in recent SCI studies have become increasingly complex, a wide range of skills and expertise is required. Cross-national collaboration may lead to debates and can thus generate new ideas and viewpoints [38].

Over the 1987–2018 period, the SCI research community were divided into 1) the core cluster led by the United Kingdom; 2) a peripheral cluster comprising Malaysia and Nigeria; and 3) a peripheral cluster comprising Canada and the United Arab Emirates. The core cluster led and influenced the direction of SCI research, and can effectively tap the knowledge resources of the global research community [39]. Over the 30-year period, researchers from India, Brazil, Greece, Japan, and Russia did not collaborate with their counterparts in other countries. Six co-authored SCI papers were published in India, forming an independent research community.

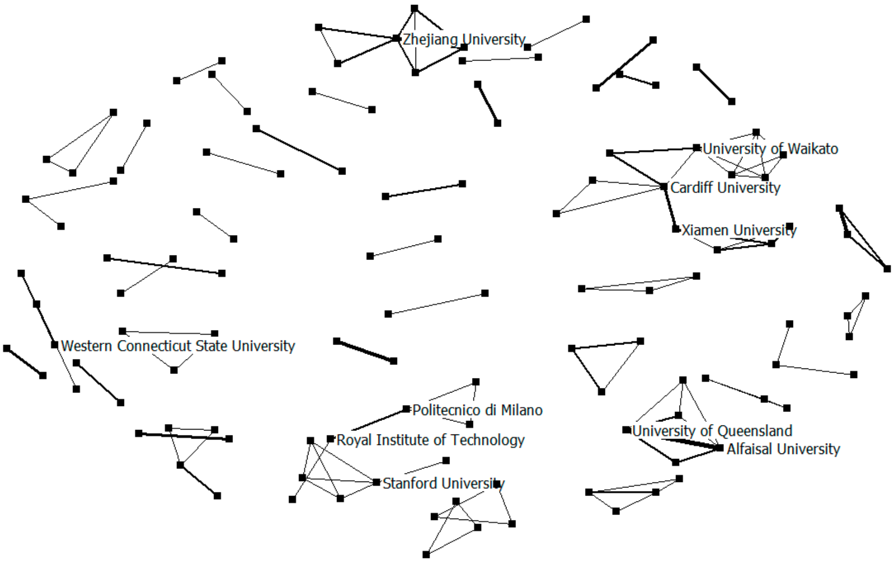
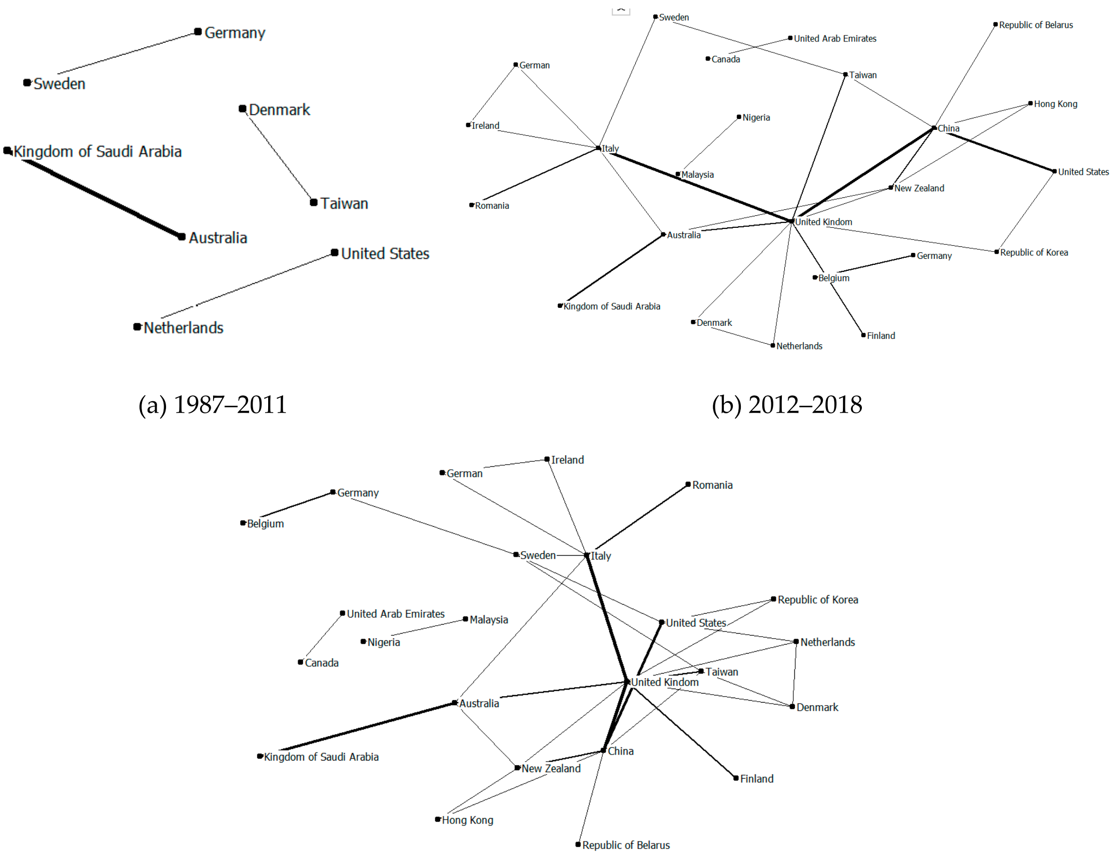


Figure 3. Institutional collaboration networks in supply chain innovation. Notes: 54 articles among 123 institutions.



(a) 1987–2011 (b) 2012–2018

(c) 1987–2018*

Figure 4. International collaboration networks in supply chain innovation. * 30 articles among 25 countries during 1987–2018

3.3. Theory Analysis

Table 5 provides the frequency that various theories were used in the sampled SCI-related articles. Approximately 30% of the articles adopted theories to discuss SCI over the 30-year period. More than 80% did not use any theory over the 1987–2011 period; however, this figure dropped to approximately 64% over the 2012–2018 period. Throughout these 30 years, the most-used theories were dynamic capability (*n* = 9) and the resource-based view (*n* = 9), whereas the second most-used were the resource-advantage (*n* = 3) and transaction cost (*n* = 3) theories.

Table 5. Theory profile.

Theory	1987–2011	2012–2018	Total
Resource-based view	1	10	11
Dynamic capabilities theory	2	8	10
Resource dependence theory	2	1	3
Resource-advantage theories	0	3	3
Transaction-cost theory	1	2	3
Contingency theory	0	2	2
Game theory	1	1	2
Innovation diffusion theory	0	2	2
Social exchange theory	0	2	2
Others	0	9	11
Total	7	40	47

Note: The theories above were used 47 times in 33 articles.

4. Discussion and Conclusions

Considering the significance of innovation for businesses, supply chains, and the wider industry, this study sampled English-language research papers on SCI, published from 1987 to 2018, to identify trends in SCI research. We found that SCI-related articles were first published in 1987; then, the number of articles was low, which increased substantially to 8 in 2012. The systemic literature review in this study analyzed SCI-related studies from the perspectives of research funding, research topics, author's collaborative relationships, and theories. We note the following implications and limitations, as well as future research directions based on its findings.

4.1. Implications

The results of the descriptive statistics suggest that over 70% of sampled SCI-related studies were not funded. Research grants enable the production of new knowledge [40]. Performance-oriented ex ante review of research proposals can inhibit the development of studies, particularly those in emerging fields [32]. The same applies to SCI, an emerging topic of supply chain research. Although SCI has been discussed from various perspectives, more research is required to understand this topic. As a result, scholars focus primarily on topics like greenness, collaboration, and managerial function. Greenness and the environment have become the main challenges for regional and global sustainable development [9]. Generally speaking, companies are limited by their own capabilities and do not possess all the resources necessary for innovation. The main reason for collaboration is to obtain such resources, especially knowledge, from other companies [41].

SCI research is concentrated in the United States, and did not receive much attention in Europe and Asia until 2012. This is consistent with the findings of Gao, Xu, Ruan and Lu [9], who found that selection of the study site depends largely on the size of gross domestic product (GDP). GDP grows faster in India, China, South Korea, and Taiwan than in Western countries [8].

There was a shift in article publishing from single authors towards collaboration. However, the number of articles written through cross-sector collaboration declined. Some researchers have highlighted the necessity for increasing their influence on industry [42,43]. Academic research differs considerably from managerial practices because both have varying assumptions and beliefs [44]. Numerous critical studies are based on researchers' practical experiences and face-to-face interactions [35]. Such studies can be performed through collaboration between academia and industry. SCI is an emerging field of research with disproportionate collaboration between scholars who have yet to develop close connections.

This study revealed that some institutions in the SCI research community were situated in the position of a structural hole, which disseminates information and knowledge in a social network [45]. When these institutions collaborate with more partners to conduct SCI research, they gain more social capital. Additionally, although a majority of SCI studies were conducted or published in the United States, it was not the center of the core cluster. This suggested that the authors made more collaborative efforts with scholars outside the United States. Over the 2012–2018 period, the United Kingdom was at the core of the SCI research community, largely because British researchers conducted more cross-national research than their counterparts in other countries. This indicates a possibility that SCI-related articles from the United Kingdom would be cited more frequently.

A growing number of recent SCI studies have applied theories, and the adopted theories have also been increasingly diverse. This trend corresponds with the recommendation of Carter and Rogers [15] that theories should be connected to investigate SCI topics. Specifically, more theories should be developed for and applied in supply chain management research. Additionally, to extend supply chain management to social and environmental contexts necessitates the introduction of more perspectives to pave the foundation for developing creative solutions and new theories [46].

4.2. Limitations

This study has some limitations. First, only the exact keywords "supply chain innovation" and "logistics innovation" were used to retrieve articles from Scopus and Web of Science; therefore, SCI-related articles with other keywords might have been ignored. However, we argue that the sampled articles were adequately representative of SCI research. Second, this study collected research papers written in English and excluded conference papers, notes, commentaries, books, magazines, and trade publications. Third, many of the trends we identified in this study were based on the SCI-related articles that were rigorously selected. Lastly, the findings and their implications depended to a great extent on the experiences and educational background of the reviewers.

4.3. Future Directions of Research

The findings of this study indicate that SCI research still has a large scope for growth. Based on the literature review, we suggest the following directions for further SCI research:

1. SCI-related articles retrieved by this study appear in various fields, suggesting that SCI concerns diverse disciplines and industries. Accordingly, not only manufacturing, but also service, agricultural, and transport industries have improved the efficiency of their respective supply chains through innovation [9]. Moreover, the average number of authors per SCI article has increased. Thus, conducting SCI studies in a cross-disciplinary setting will be a trend in the foreseeable future, yielding insightful findings for industrial communities.
2. Only 15% of SCI-related studies sampled by this study focused on more than two countries. Most studies focused on a single country. In the competitive global market, it can be assumed that the raw materials of a product are produced in one country, whereas its production, assembly, transportation, and sales occur in various other countries. Therefore, future researchers should conduct SCI research at a cross-national level to analyze the generalization of SCI. This is because when innovation is integrated into the global supply chain, stakeholders can benefit.
3. SCI research is currently benefiting from cross-national collaboration and, thus, is developing rapidly. Future SCI studies should be conducted based on collaboration between academia and industries to narrow the academia–industry gap and develop new research topics.

4. The SCI research community is still developing. The country or institution at the center of a core cluster of collaboration networks for SCI research should promote and fund SCI research to acquire critical information and benefits. Both research and business organizations can benefit accordingly. This study analyzed the SCI research community on the scale of collaboration networks. Future studies can discuss such networks by examining relevant abstracts and keywords or using relevant methods.
5. This study found that "adoption," collaboration," and "green/sustainable development" have remained popular topics among SCI researchers. These topics can be investigated by using various stages or forms of SCI, or on a cross-national basis.
6. This study showed that dynamic capabilities and the resource-based view are the most used theories in SCI research. Future studies should analyze the role of both theories in SCI research and conduct a citation analysis of the theories to improve understanding of the development of SCI research.

Author Contributions: Conceptualization, C.-H.Y. and Y.J.W.; Methodology, C.-H.Y. and K.-M.T.; Formal Analysis: Y.J.W. and K.-M.T.; Writing, C.-H.Y., Y.J.W., and K.-M.T.

Funding: This research was funded by University of Electronic Science and Technology of China, Zhongshan Institute (No. 418YKQN05).

Conflicts of Interest: The authors declare no conflict of interest.

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